Session Descriptions

May 16, 2001--Day 1

Pioneer Technology Innovation:

In order to develop the aerospace systems of the future, revolutionary approaches to system design and technology development will be necessary. Pursuing technology fields that are in their infancy today, developing the knowledge bases necessary to design radically new aerospace systems, and performing efficient, high-confidence design and development of revolutionary vehicles are challenges that face us in innovation. These challenges are intensified by the demand for safety in our highly complex aerospace systems. The goal to Pioneer Technology Innovation is unique in that it focuses on broad, crosscutting innovations critical to a number of NASA missions and to the aerospace industry in general. NASA's latest accomplishments include demonstration of a heterogeneous distributed computing environment, a test of a shape memory alloy to control flow into an engine inlet, and a full-scale test of a composite wing box that performed as predicted.

Moderator: Dr. William Ballhaus, Jr., President, The Aerospace Corp.

Panel Members:

Mr. Howard Bloom, NIST Director of Manufacturing Engineering Laboratory (MEL)

Dr. Rich Wlezien, Program Manager, Quiet Supersonic Transport (QST), DARPA

Dr. Richard E. Smalley, Director, Rice Center for Nanoscale Science & Technology, Rice University

Mr. Michael Hudson, Vice Chairman, Rolls-Royce North America

Dr. Darrel Tenney, Director, Aerospace Vehicle Systems, NASA-LARC

NASA Turning Goals Into Reality Conference
Innovation in Aerospace Transportation

Pioneering Technology Innovation in Aerospace Vehicle Systems

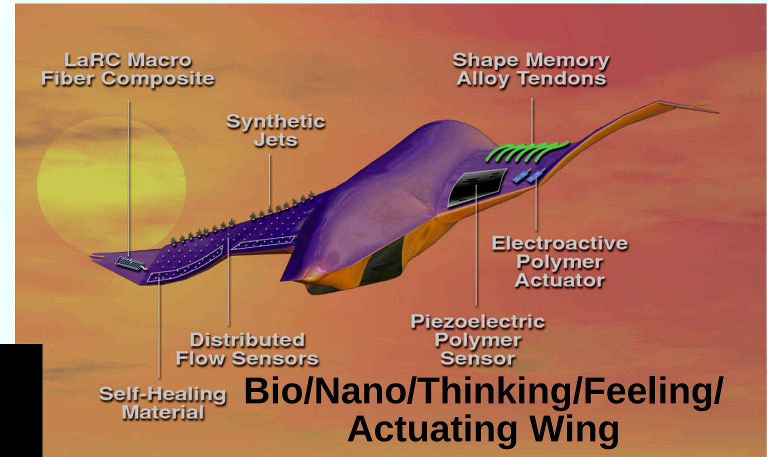
Dr. Darrel R. Tenney
Director Aerospace Research Office
NASA Langley Research Center

Ronald Reagan International Trade Center
Washington, D.C.
May 15-17, 2001

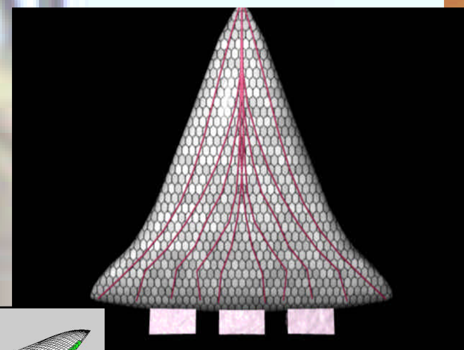
Towards Advanced Aerospace Vehicles

Aerospace Vehicle Includes:

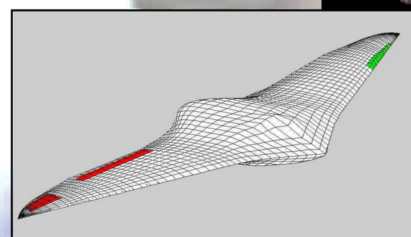
- Distributed self-assessment and repair
- Real-time, multi-point reconfiguration
- Adaptive virtual (aerodynamic) shape change
- Adaptive structural shape change
- Biologically-inspired concepts
- Seamless wings
- Multi-functional, active structures



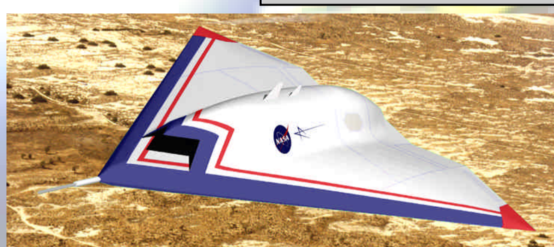
Bio/Nano/Thinking/Feeling/ Actuating Wing

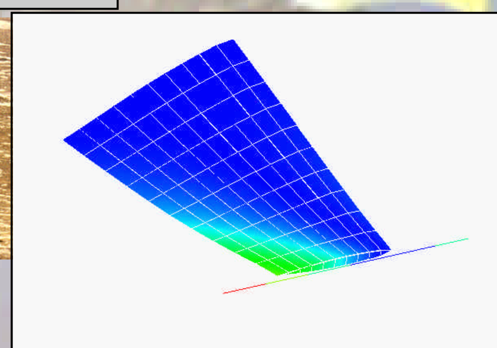


Smart Flow Control Wing with Holistic Health Monitoring



Smart Composite wing with Active Flow Control





Aeroelastically Tailored Wet Composite Wing

Modern Advanced Airfoil Metal Wing

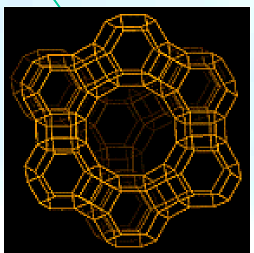
Advanced Technology Development

Time

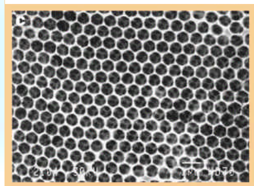

Efficiency:
Wingtip Flow
Control
Safety:
Full Situational
Awareness
Propulsion:
Highly Distributed
and Ultra-Efficient
Survivability:
Distributed Nervous System
Self-Healing Systems
Morphing:
Continuous Optimal
Shape Control
Strong, Lightweight:
Integral Wing-Body
Structure
Agility:
Extreme
Maneuverability

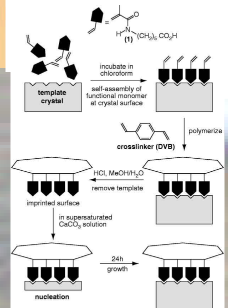
Revolutionary Technologies

Biotechnology

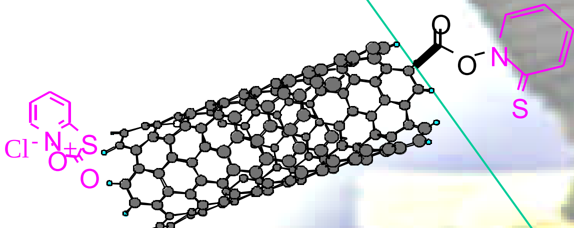


Templates



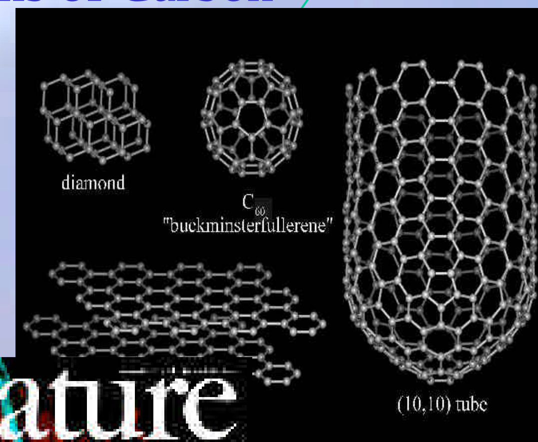


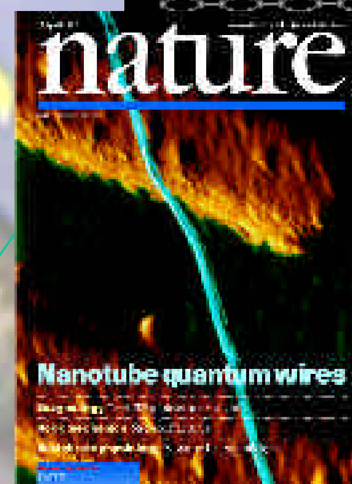
Functionalization



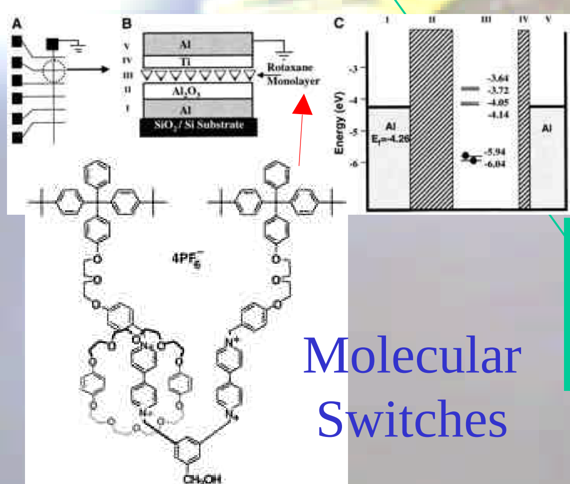
Nanotechnology

The Forms of Carbon





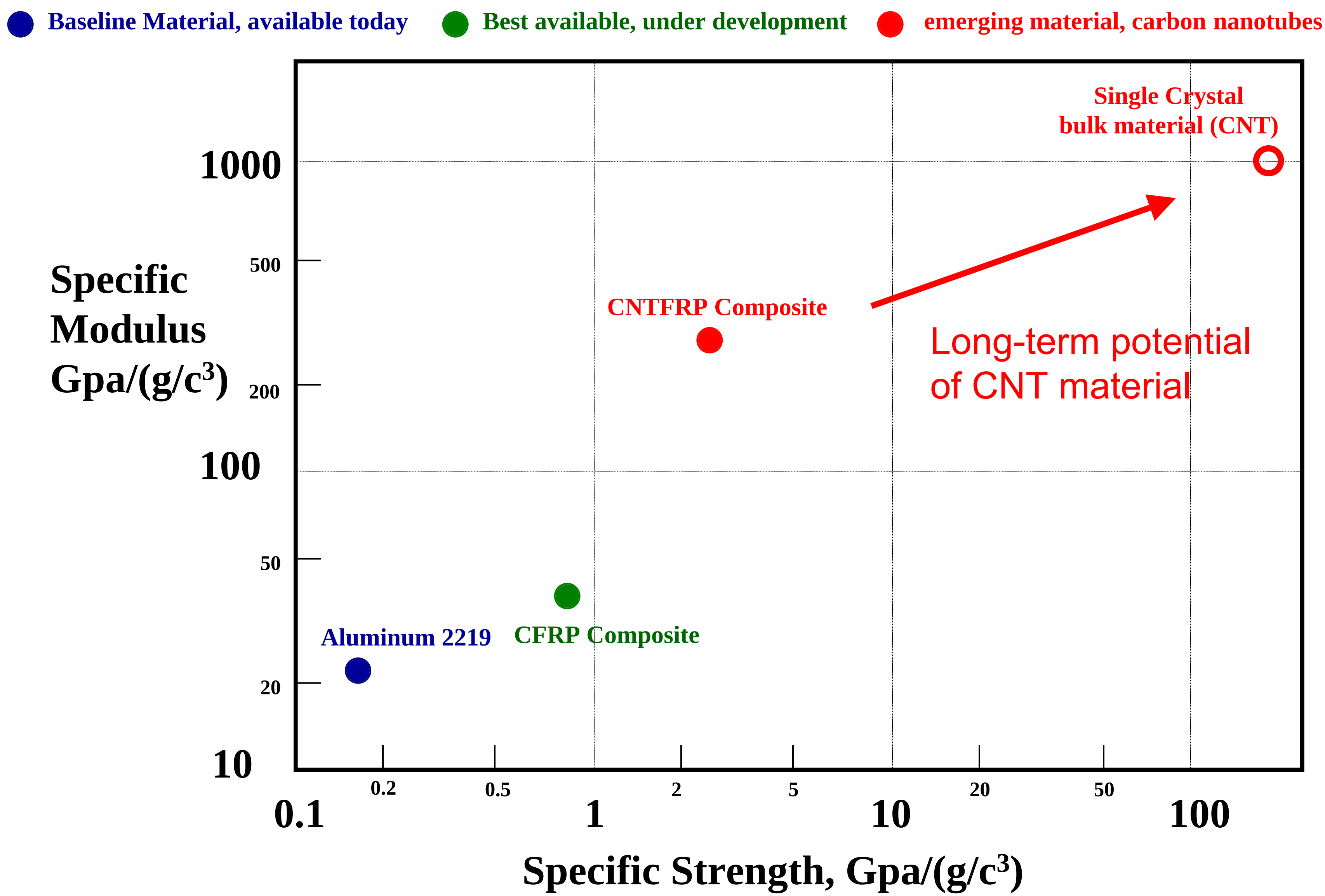
Nanotubes



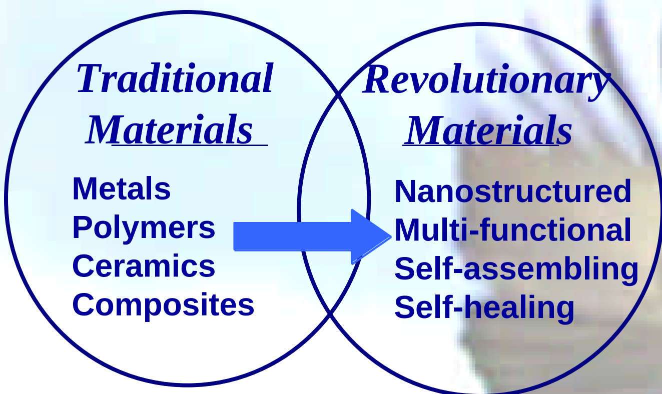
Molecular Switches

Information Technology

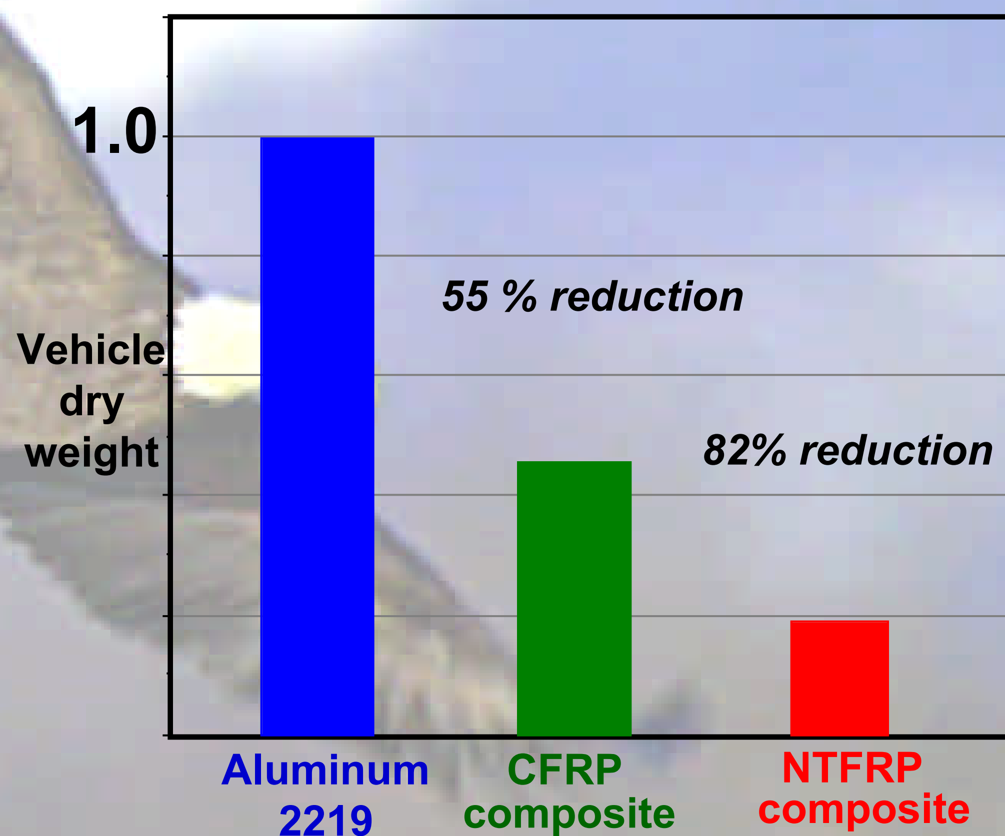
Properties of Carbon Nanotubes (CNT)



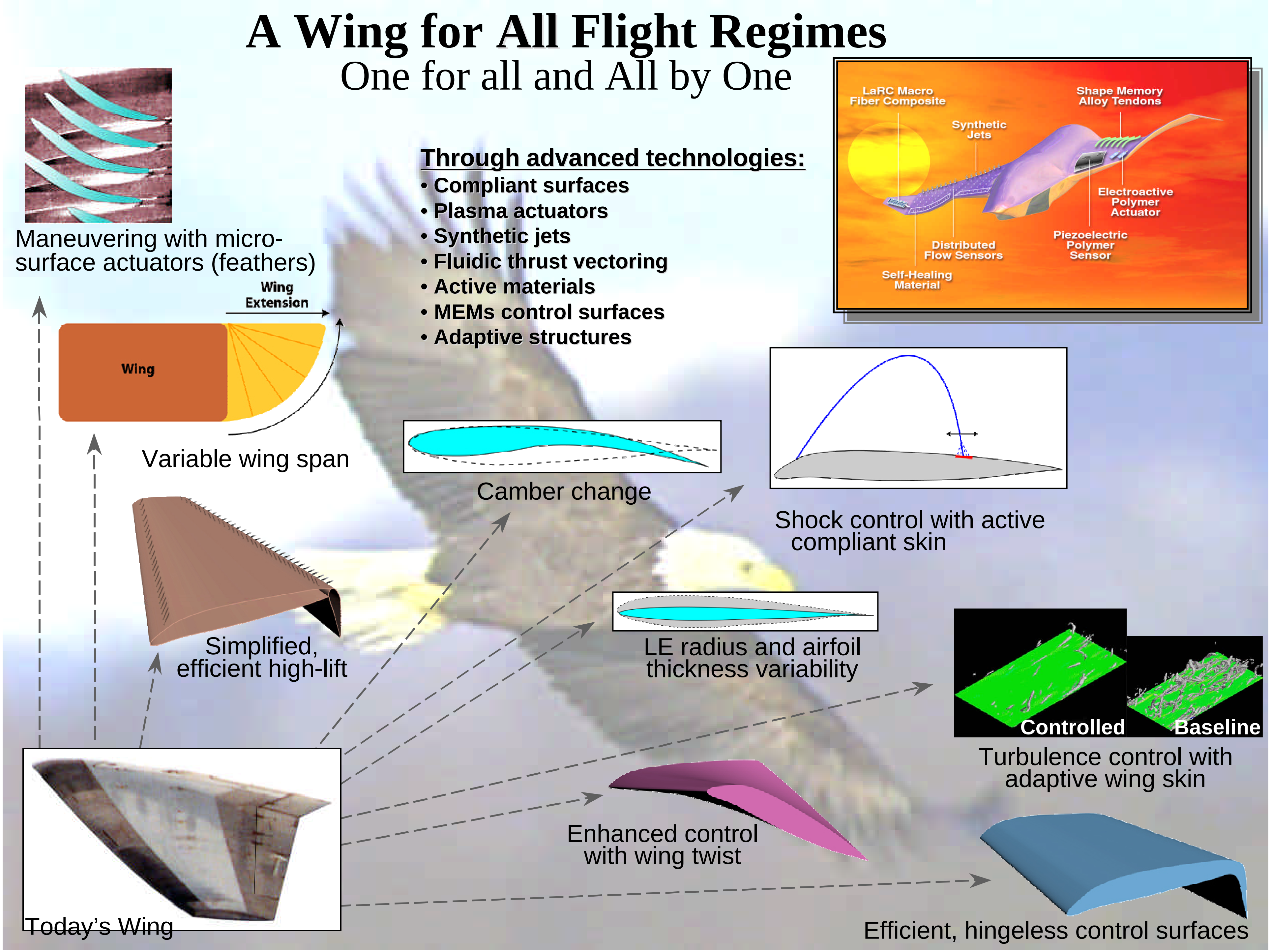
Carbon Nanotube Composites for Aerospace Vehicles



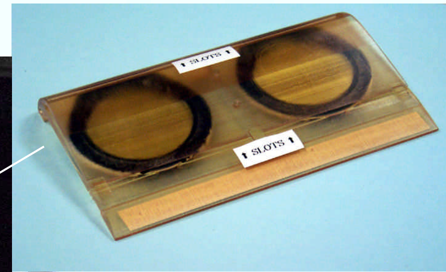
The Nanotube Fiber Reinforced Polymer Composites (NTFRP) compared to an advanced Carbon Fiber Reinforced Polymer (CFRP) composite



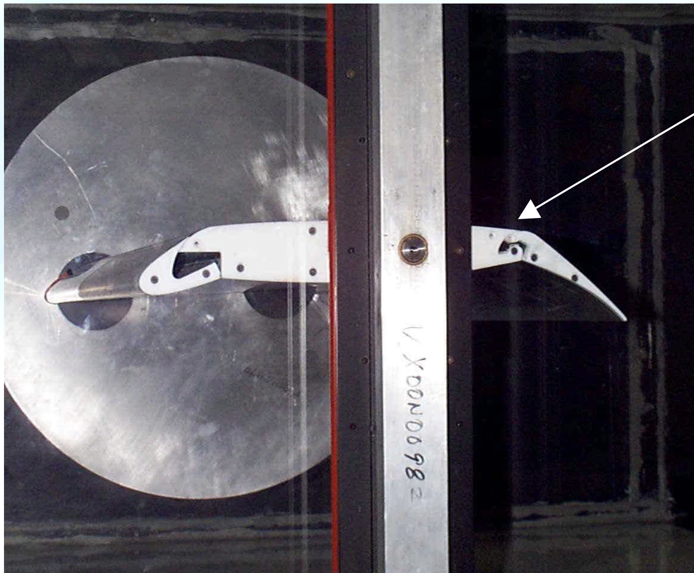
Reusable Launch Vehicles


A Wing for All Flight Regimes
One for all and All by One
Through advanced technologies:
• Compliant surfaces
• Plasma actuators
• Synthetic jets
• Fluidic thrust vectoring
• Active materials
• MEMs control surfaces
• Adaptive structures
Maneuvering with micro-surface actuators (feathers)
Wing Extension
Wing
Variable wing span
LaRC Macro Fiber Composite
Synthetic Jets
Shape Memory Alloy Tendons
Electroactive Polymer Actuator
Piezoelectric Polymer Sensor
Distributed Flow Sensors
Self-Healing Material
Camber change
Shock control with active compliant skin
Simplified, efficient high-lift
LE radius and airfoil thickness variability
Controlled
Baseline
Turbulence control with adaptive wing skin
Enhanced control with wing twist
Efficient, hingeless control surfaces
Today's Wing

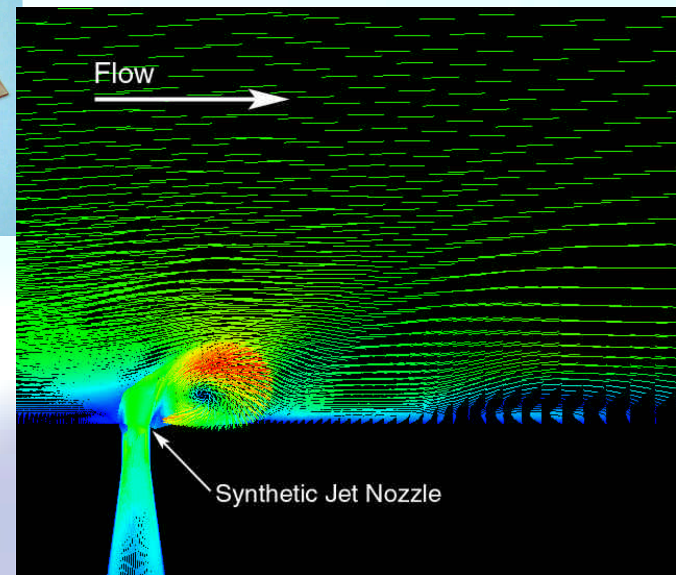
Sample of NASA Langley Research in Active Flow



Synthetic Jet



Model installed in tunnel



Numerical simulation of synthetic jet

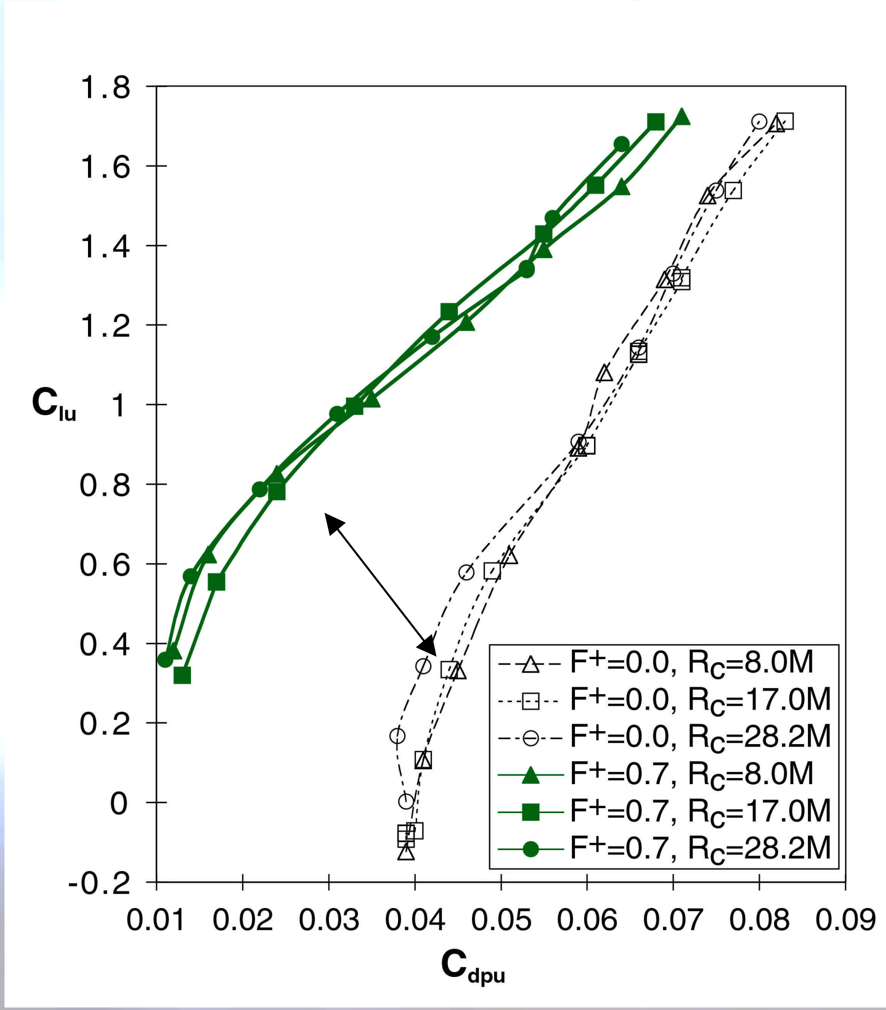
Simplified High Lift System

- Integrates many of the advanced technology development areas at Langley
- Langley has demonstrated separation control to actual flight conditions
- Periodic excitation produces benefits with 100X less energy input
- Increased lift by 20-70%, decreased drag by 30-50%, improved stall characteristics

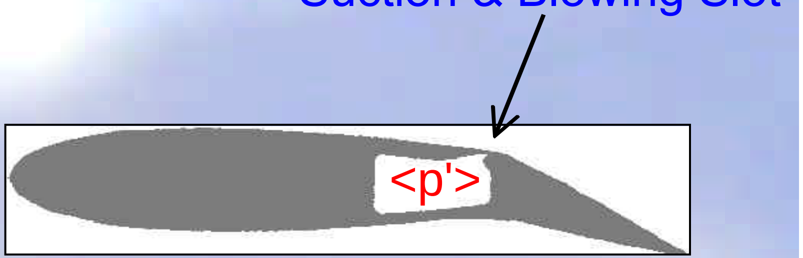
Synthetic Jet Actuators

- Electrically driven by vibrating membranes in cavity using smart materials
- Adds unsteady momentum and vorticity to external flow through jet nozzle
- Fast actuation for excellent control response
- Synthetic jets provide additional weight benefit by requiring no plumbing or pumps
- Small and redundant for improved system reliability and safety

Takeoff/Landing Applications: Separation Control



Takeoff & Landing Conditions



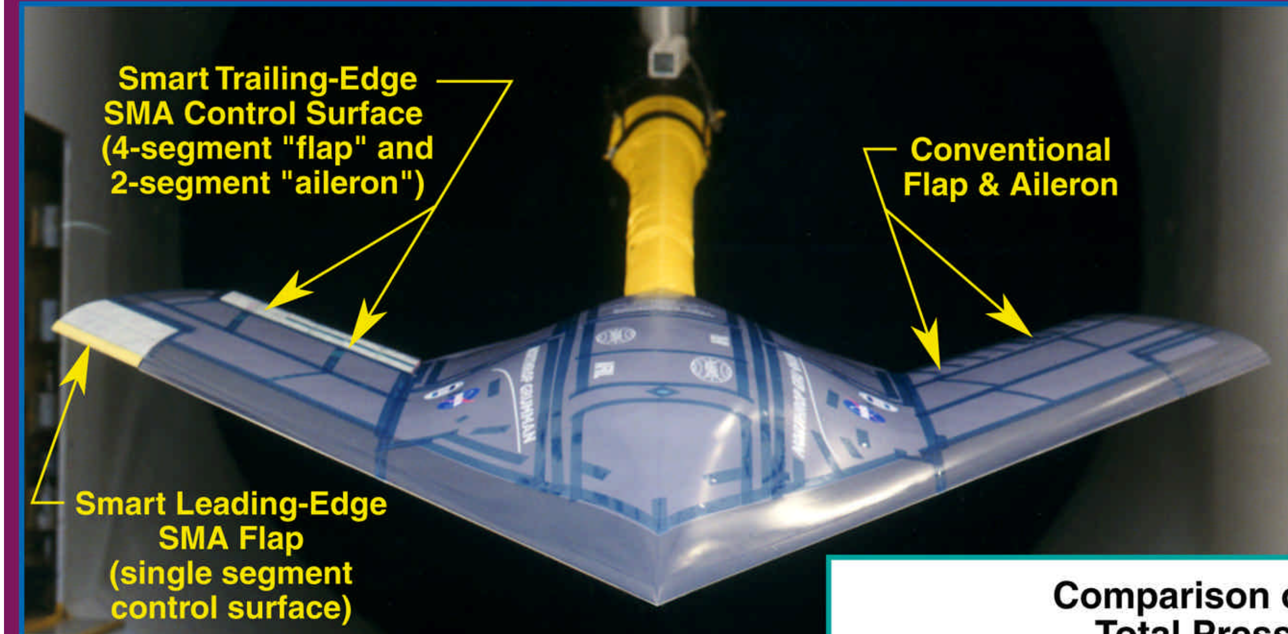
- 30-50% Drag Reduction
- 20-70% Lift Increase
- 2 orders of magnitude less mass flow required compared to steady blowing
- Independent of Reynolds number

Seifert & Pack, AIAA-98-0214

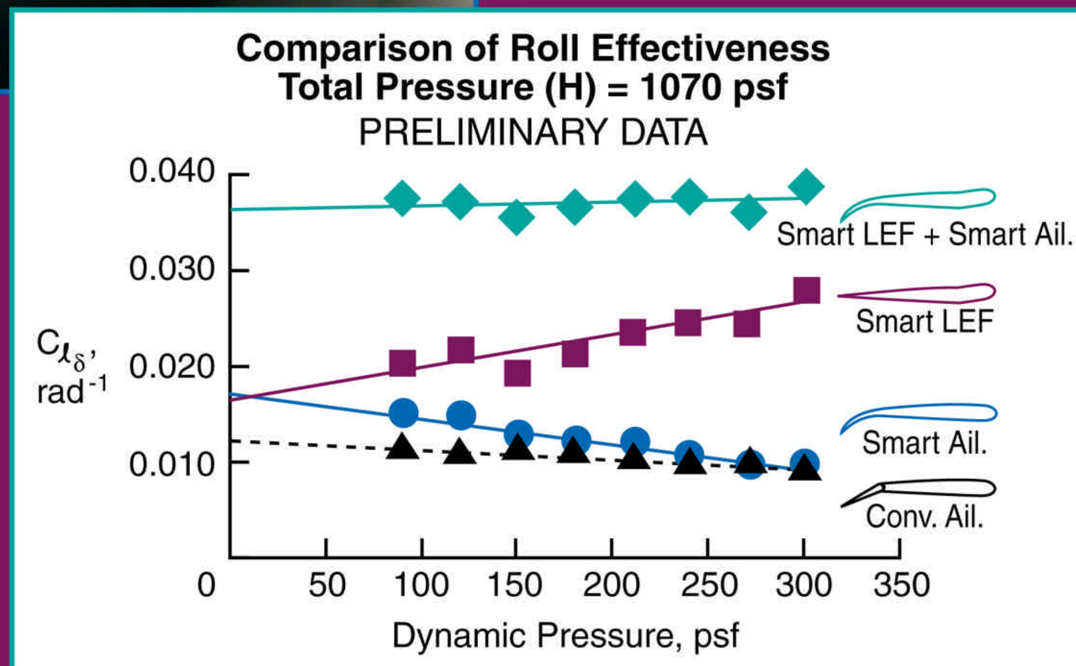
NASA Simplified High Lift System: Motivation
(System Study Results)

- **Two industry system studies confirm that simplified high lift systems provide the highest payoff for conventional vehicle designs**
- **$410K manufacturing cost savings on $30M airplane**
  - 2.6% reduction in part count
  - 3.3% reduction in empty weight
- **Yearly savings of $45M in fuel costs per airline**
  - Based on estimates of Delta Airlines 1998 and 1999 fuel consumption
  - 3.3% reduction in cruise drag
- **More significant gains possible with vehicles designed from the conceptual stage with integrated active flow control**

DARPA/AFRL/NASA/NORTHROP GRUMMAN SMART WING PHASE II, TEST 1 COMPLETED IN THE TDT



NORTHROP GRUMMAN
Military Aircraft Systems Division

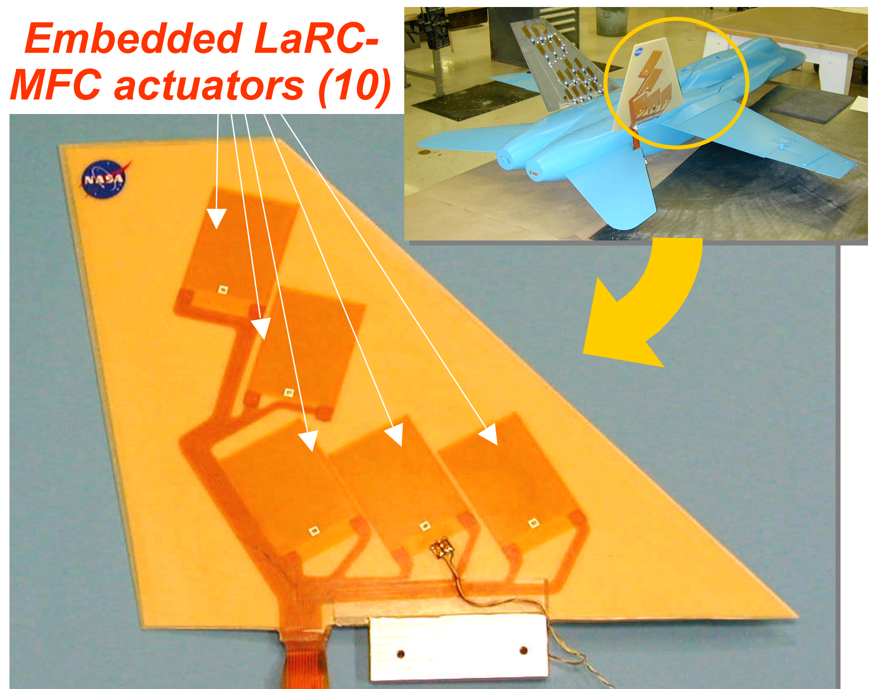


LaRC Macro-Fiber Composite -FY00

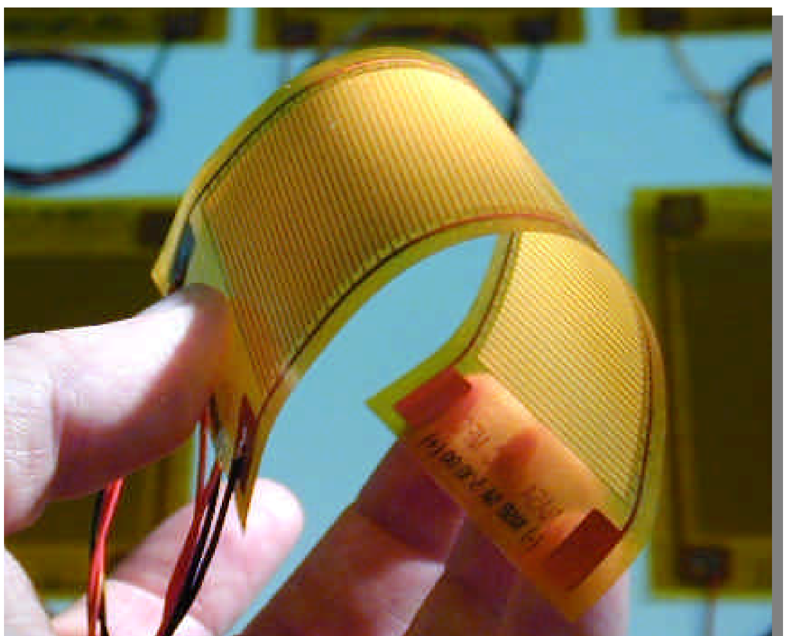
- **R&D 100 Award and Editor's Choice**
- **Vibration Suppression Demonstrated in an Inflatable Strut**
- **Buffeting Alleviation Demonstrated in Wind-Tunnel Test (L2 Milestone)**

Z-folded strut containing LaRC-MFC actuators

Embedded LaRC-MFC actuators (10)



LaRC-MFC 1/6th scale active tail model



Macro-Fiber Composite

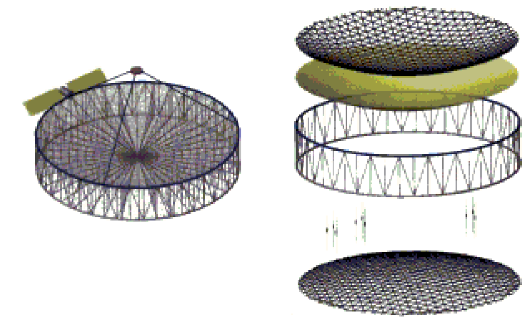
- 2000 R&D 100 Award and Editors' Choice
- Flexible, durable, cost-competitive, easily manufactured piezoelectric device
- Conforms to surfaces and can be embedded in or attached to flexible structures
- Senses strain and moves to dampen vibration or position smart structures

Smart, Ultralight Deployable Spacecraft

1. LaRC-MFC devices embedded in inflatable composite struts and folded for launch

2. Struts inflated and cured on-orbit

3. Used as structure in ...



Very large precision antennas reflectors, and mirrors

Solar sails with controllable spars

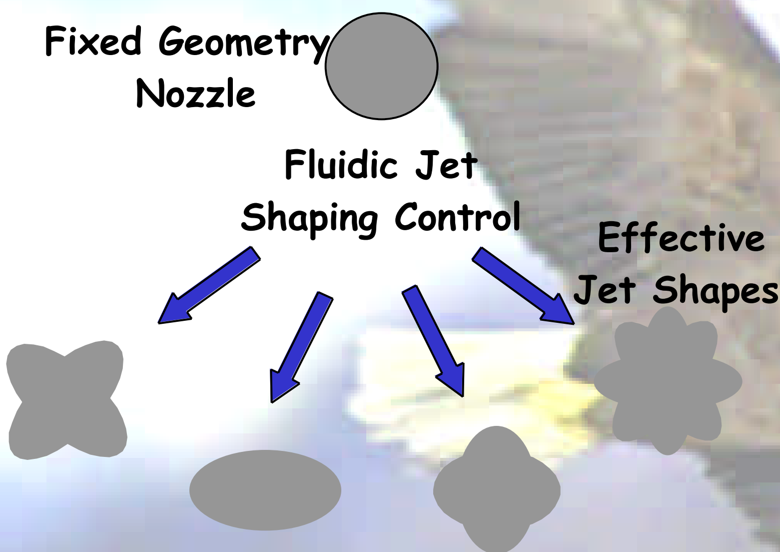
20 Fold Reduction in Vibration Using Smart Actuators Enables Deployable Structures Technology

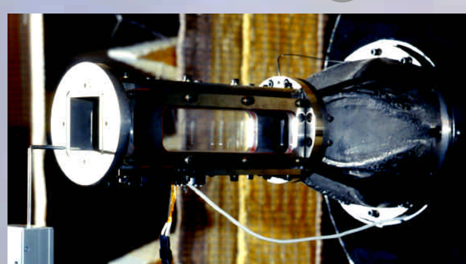
Noise Attenuation

J. Posey

Active Control of Jet Noise

- Control of jet instability modes
- Jet shaping
- Piezoelectric and glow discharge



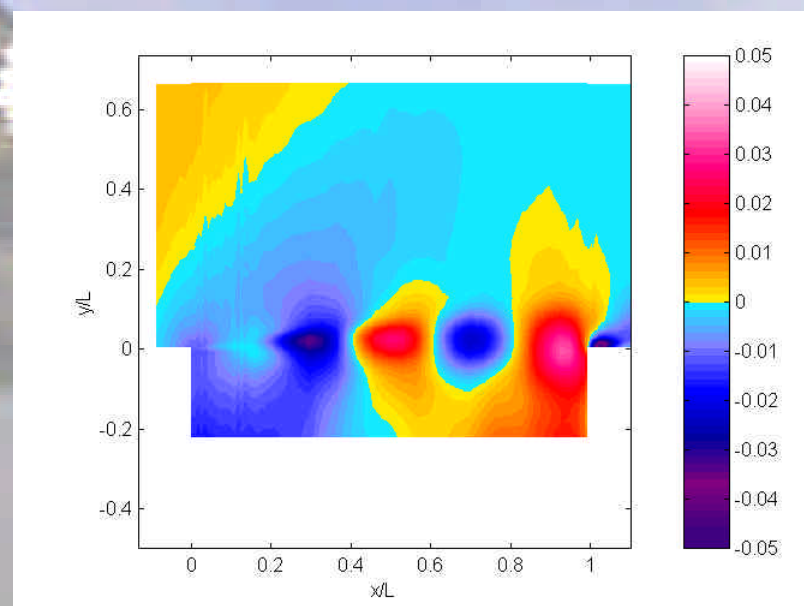


AB - Kevin Kinzie

Closed-Loop Control of Cavity Shear Layer Instabilities

- Multiple mode control

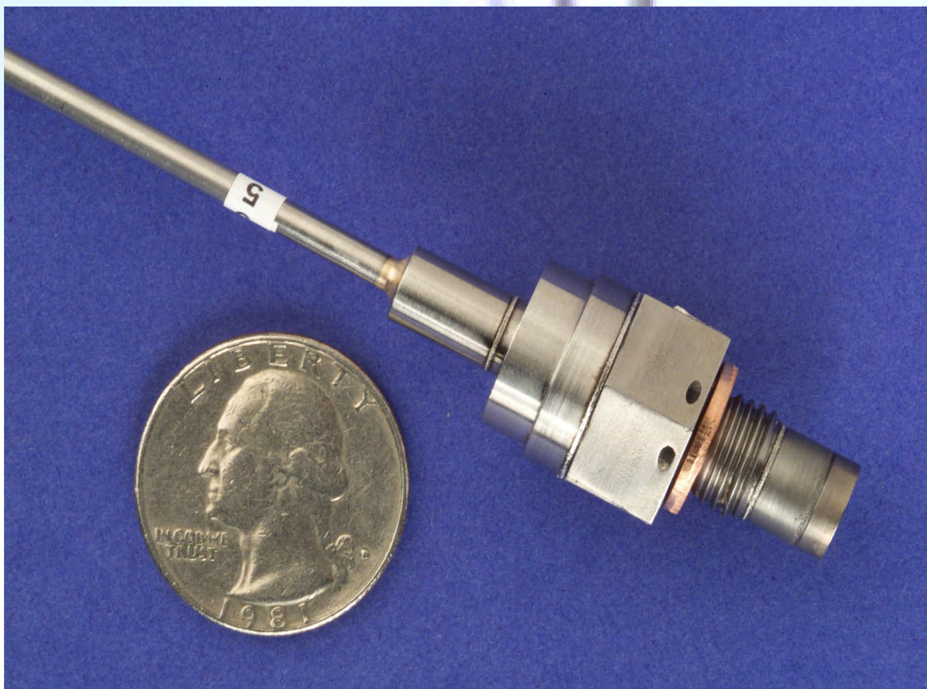
Mode 3 in Mach 0.6 cavity

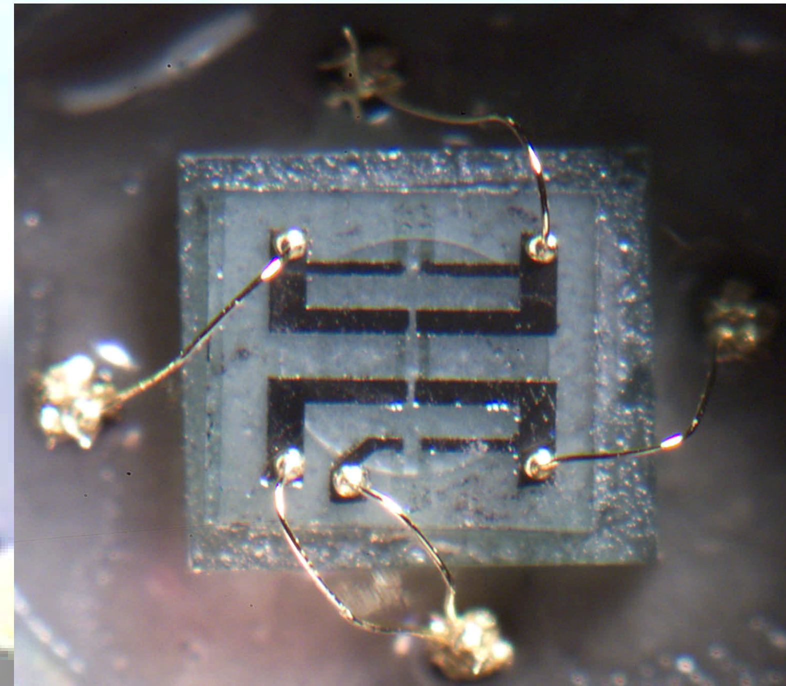


FPCB - Mike Kegerise

Hyper-X FFS/HXFE Yaw Effects Test

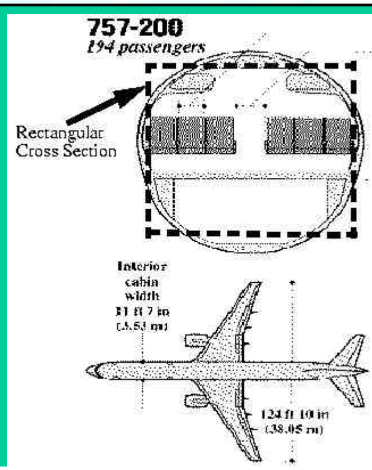
HOTPC TECHNICAL ACCOMPLISHMENT



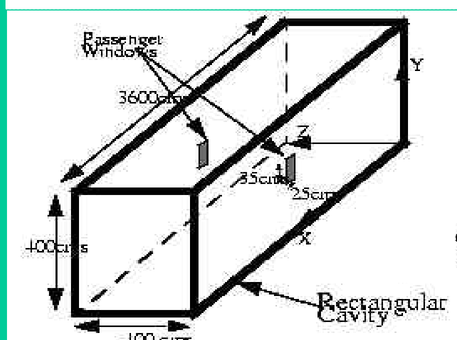


- High Temperature SiC technology developed by the HOTPC Project at GRC
- Packaging and Laboratory Demonstration performed by Kulite Semiconductor Products through an SBIR
- Engine and Test Provided by Honeywell through PIWG (Propulsion Instrumentation Working Group) that fosters pre-competitive collaboration between aircraft engine companies and the federal government on the development of advanced instrumentation.

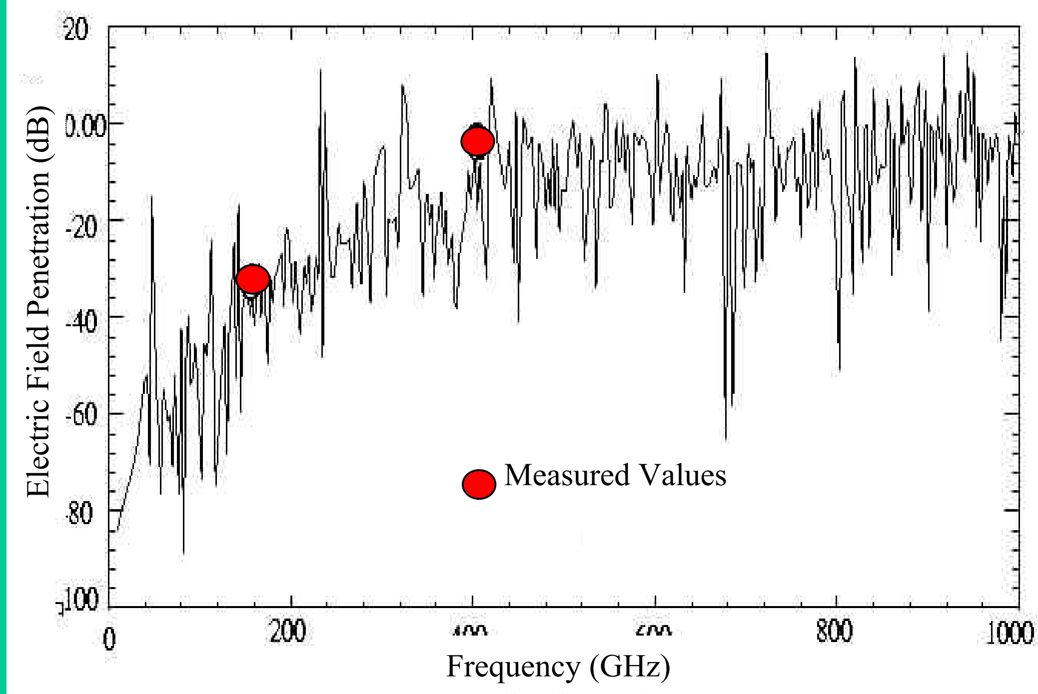
Computational Electromagnetics
Validation of Modal/MoM code for Field Penetration



Model for Field Penetration



Radar Field Penetration into Cabin of B757



- **What Has Been Accomplished?**
  - **New technique and code development for efficient modeling of EM field penetration through holes in very large cavities. Code has been validated with measurements inside actual aircraft cabin region. Code was used in TWA-800 investigation report, which was selected for H.J.E. Reid award.**
- **Significance?**
  - **Capability exists for extensive aircraft safety studies related to EM field upset potential.**

Final Demonstrations of TAP Technologies

PCA Milestone: Completed demonstration of all TAP developed technologies and procedures (9/00)

Field Demo of Aircraft Vortex Sensing System

757 Research System Flight Demonstration

CTAS/FMS Flight and Full-Mission Simulation

Field Demo of Low-Visibility Landing and Surface Ops

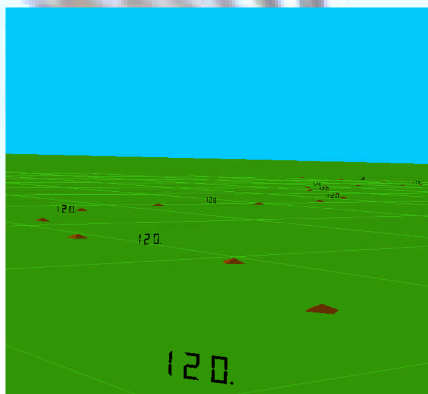
Flight Test/Sim Demo of Airborne Info for Lateral Spacing

T-NASA: A Human Factors Success Story

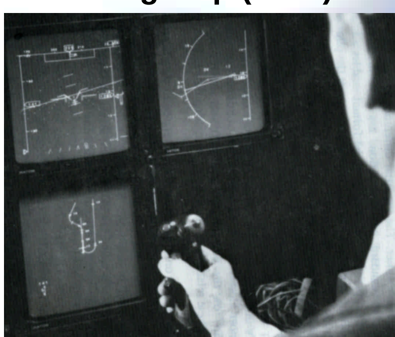
R&T Base

HUD symbology development / Attention Management (1977-1982)

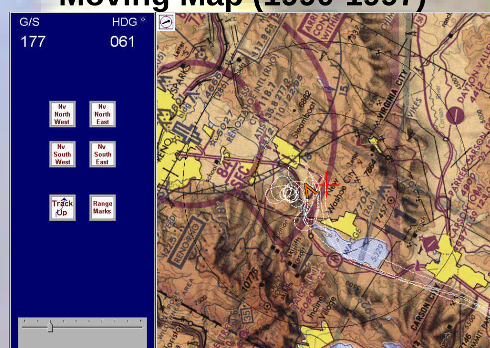
"Scene-Linked HUD Symbology" concept developed (1995)



In-flight Electronic Moving Map (1974)



Rotorcraft/Firefighter Electronic Moving Map (1990-1997)



ANDS - Advanced Navigational Display System

TAP Project

T-NASA (Taxiway Navigation and Situation Awareness) System (1995-1999)

HUD

Moving Map

Technology Transfer

Rockwell Collins/Flight Dynamics Surface Guidance System (HUD and Electronic Moving Map) Based on T-NASA concepts

Announced August 2000
Phased Certification planned 2003/2006

Concluding Remarks

• Aeronautics, Launch Vehicles, and Spacecraft require Breakthrough new Technologies to meet Future Design Challenges

• Innovative new ideas are required to expand capacity, improve safety, reduce community noise, reduce emissions and maintain an affordable air travel system for all sectors of our society

• System trade studies are required to define requirements and to assess potential payoff of new technologies to guide R&D investment strategies.

• National Investment in High Risk Innovative New Technologies for Aerospace Applications must be Increased to Insure Successful Development of Vehicles and Systems that will Improvement the Quality of life of all Americans.